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USSR Report

MATERIALS SCIENCE AND METALLURGY

(FOUO 3/82)

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FERROUS METALLURGY

PROBLEMS OF IRON AND STEEL INDUSTRY DEVELOPMENT

Moscow VOPROSY EKONOMIKI in Russian No 3, Mar 82 pp 54-59

[Article by S. Kadetov: "Economic Problems of Development of Ferrous Metallurgy"]

[Text] The CPSU Central Committee and USSR Council of Ministers decree entitled "On Intensifying Efforts to Achieve Economy and Efficient Utilization of Raw Materials, Fuel-Energy and Other Material Resources" states: "To expend raw materials and supplies carefully, to reduce waste, and to eliminate losses means to achieve savings in the labor of millions of people and capital investment, to increase output, and to protect the environment." The decree focuses the ferrous metallurgical industry on accomplishing two principal tasks -- intensification of metallurgical production and efficient utilization of resources.

The USSR contains approximately half of the world's iron ore reserves. Of the total quantity of proved reserves, approximately 15 percent are rich ores, containing on the average more than 55 percent iron and not requiring concentration, 67 percent are ores which are concentrated by simple processes, and 18 percent are ores requiring complicated concentration methods.

In the USSR the largest iron ore reserves are concentrated in the Ukraine, in the Central part of the RSFSR, in Kazakhstan, Siberia, and in the Urals, accounting for 85 percent of all iron-ore resources. For the most part rich and easily-concentrated ores are being developed in this country. Rich ores comprise 17 percent of total production. Ores requiring complicated methods of concentration are being utilized in blast-furnace production to an insignificant degree at the present time. Approximately 90 percent of the merchantable ore consumed by metallurgical plants is mined locally; the remaining 10 percent is hauled long distances. Principal growth in iron ore reserves for the immediate future is projected in the western areas of the country. In connection with this, increase in ferrous metals production is to be achieved by expanding the Staro-Oskol'skiy Electrometallurgical Combine in the area of the Kursk Magnetic Anomaly (KMA), as well as construction of second and third units of existing plants in the northeast of the European part of the country and in the Ukraine.

Studies indicate that the economic effectiveness of production of merchantable iron ore is significantly greater in the western areas of the USSR than in the eastern.[1] Effectiveness is particulary low in the Urals and Western Siberia.

The main reason for this is the absence of large surveyed ore bodies which can be surface-mined. The largest deposits in Eastern Siberia in terms of reserves are the Tagarskoye and the Nizhne-Angarskoye. The economic effectiveness of commercial iron ore production here, however, is calculated to be lower than in the western areas of the USSR. The fact is that, in the first place, a large portion of the ore requires beneficiation; secondly, rail lines must be constructed; thirdly, because of the harsh climatic conditions, pit transport vehicles, loading and other equipment must be provided in Arctic models; urban-type communities must also be built.

As calculations show, all iron ore deposits in the Urals and Siberia which are presently in operation or scheduled to go into operation have worse economic indices than ore bodies in the western areas of the country. According to the method of determining economic effectiveness of capital construction, it is advisable to build metallurgical enterprises only in the European part of the country, and the USSR Ministry of Ferrous Metallurgy has no interest in pushing industry eastward. In our opinion the existing method is little suited for the eastern parts of the country. Analyzing the reasons for increase in the cost of capital construction in the eastern regions and a decline in return on investment, Academician T. Khachaturov noted that a decline in the capital-output ratio does not constitute grounds for a decision not to build new enterprises in the eastern part of the country.[2]

The iron ore bodies of the Kursk Magnetic Anomaly are unique among the country's iron ore deposits. Proved reserves of high-grade ore total approximately 27 billion tons, and 40-50 billion tons including projected reserves.[3] The iron ore bodies of the KMA constitute the raw materials base for the Staro-Oskol'skiy Metallurgical Plant which is under construction. The mining enterprises of the KMA can meet the iron requirements of the Novo-Lipetskiy and Novo-Tul'skiy metallurgical plants and plants of Western Siberia. Considering the enormous reserves of high-grade ores in the KMA, Northern Kazakhstan and the Ukraine, the USSR Ministry of Ferrous Metallurgy is planning to obtain 80 percent of merchantable ore production increase in these areas. Of interest in this connection is the "Long-Range Capital Investment Program for Development of Ferrous Metallurgy Based on the Iron Ores of the KMA and Coking Coal of the Kuzbass." This program attempts to provide an economic substantiation of the feasibility of supplying with iron-ore resources the metallurgical plants of Western Siberia and with coking coal the plants of the central region on analogy with the Ural-Kuznetsk metallurgical base. The KMA-Kuzbass program, however, should be viewed as a reserve program. If large and economical iron ore deposits are discovered in Western Siberia in the near future, there will be no need to implement this program.

The percentage share of surface-mined iron ore is increasing at present. From 1970 to 1980, for example, the share of surface-mined production increased from 79 to 82 percent, while the share of underground-mined production declined from 20.8 to 16.1 percent. Subsequently the ratio of these two modes of production will stabilize. Surface mining of iron ore is much more economical. Specific capital investment per ton of production increase in merchantable ore with underground mining is 11 times greater than with surface mining. Continuing underground mining operations, however, is dictated both by a shortage of iron ore deposits capable of supplying existing metallurgical plants and by the conditions of occurrence of natural high-grade iron ores. In the future a number of surface mines will exhaust reserves at the upper levels and will in part shift to mixed modes of production. Subsequently there will evidently be a decline in the percentage share of surface-mined production. This is based on the assumption that practically all known large deposits where mixed-mode production will be employed will have been brought into operation. One should bear in mind thereby that open-pit mining is accompanied by removal from use of large acreages of fertile land. For example, exploitation of the KMA iron ore bodies led to the removal of approximately 15,000 hectares, including 9000 hectares of arable land. A comparison of the acreage occupied by the underground and surface mines of the KMA shows that only 1200 hectares are required for the underground Yakovlevskiy and Gostishchevskiy mines for the entire period of exploitation, while approximately 20,000 hectares are required for the Stoylenskiy, Lebedinskiy, and Mikhaylovskiy surface mines.

Ferrous metallurgy in the USSR is developing in conformity with the directions specified at the 25th and 26th CPSU congresses -- increasing the unit output of metallurgical equipment and intensifying the process of concentration of metallurgical production, a result of which is an increase in steelmaking at metallurgical plants of up to 10-25 million tons per year. This ferrous metallurgical industry growth focuses the iron ore industry toward increasing the percentage share of large surface-mining operations. In the future the percentage share of open-pit mines with an annual crude ore output of 20-30 million tons or more will increase to 60 percent of the total volume of surface-mined ore production. In spite of this, however, concentration of production in the iron ore industry still lags behind the demands made by blast-furnace production. At the present time all metallurgical plants are consuming iron ore from a group of ore bodies, which involves worsening of the technical-economic indices of pig iron production. In addition, there arises the problem of blending the raw materials at storage sites, which causes additional costs. Existing equipment is unable to provide proper blending. As a result iron content in the sintered ore fluctuates ±1-2.0 percent. At ore blending facilities abroad this ratio runs as follows: 0.2 percent in Japan, and 0.25 percent in the United States. Providing Soviet sinter plants with modern blending equipment will make it possible to boost the productivity of blast furnaces and improve the economic indices of blast-furnace production.

Expenditures involved in mining and preparing ore for smelting are taking up an increasingly larger share of production cost. Increase in the cost of the processes of preparing ores for smelting has been caused by objective factors. In 1958, for example, 1.3 tons of crude ore were required to produce a ton of merchantable ore, while in 1965 the figure was 1.6 tons, 1.85 tons in 1971, and 1.92 tons in 1980. The increased amount of crude ore required to produce a ton of merchantable ore is due to the limited reserves of high-grade iron ores and the uneven geographic distribution of these reserves in this country; the large-scale utilization of low-grade ores requiring beneficiation, and impoverishment of a portion of high-grade ores as a result of working ore bodies with high-output mass caving systems, etc. All this inevitably leads to an increase in the percentage share of beneficiated iron ore in the total production volume and to expanded construction of beneficiation plants at practically all surface and underground mines coming into production. Similar results are brought about by a decline in the percentage content of iron in the mined ores. For example, the percentage content of iron in the crude ore declined from 37.3 to 35.1 percent from 1970 to 1980.

Improvement in the quality of iron ore and increase in the iron content in the merchantable ore takes place in the process of beneficiation. A trend toward increase in iron content in concentrate is becoming increasingly more marked, since the savings achieved in blast-furnace production by smelting high-grade ore exceeds by severalfold the expenses involved in high-concentration ore beneficiation and concentrate pelletizing. In addition, beneficiation of iron ores on the one hand reduces the cost of producing pig iron, while on the other hand it fosters technological advances in the iron and steel industry.

Iron content in concentrate is higher in the USSR than in the United States. Plans for new Kursk Magnetic Anomaly mining and beneficiation combines call for obtaining concentrates with a 67-68 percent iron content. The performance indices of these enterprises are equal to those of foreign enterprises in quality of concentrates and fineness of the final grind. Large capital investment is required, however, to achieve such results. Expenditures on construction of new, renovation and expansion of existing crushing-sizing and beneficiation plants make up a substantial percentage share of the total amount of capital spending in the iron ore industry.

Growth in fixed assets at crushing-sizing and beneficiation plants is running ahead of increase in volume of concentrate, resulting in a worsening of the output-capital ratio at ore preparation enterprises and reduced return on capital.

Employment of high-concentration beneficiation and utilization of the most modern equipment inevitably raise the cost of beneficiation and specific outlays per ton of concentrate. According to the figures of N. Lelyukhina,[4] with a 1 percent increase in iron content in magnetic concentrate within the range of 60-65 percent, the cost of the concentrate increases by 10-20 kopecks, and specific capital outlays (figuring mining of quartzites) by 50-65 kopecks. The savings obtained in producing pig iron, however, exceed by 3-4-fold outlays connected with increasing iron content.

Increase in the economic effectiveness of beneficiation of iron ores is determined in large measure by the comprehensiveness of their utilization. Solving the problem of comprehensive utilization of complex ores will make it possible to reduce the cost of producing the main product and to obtain a number of associated constituents. The difficulty here lies in the fact that the iron and steel industry will be compelled to turn out products of other branches: sludges for fertilizing soil, rare elements, building materials, etc. The lack of interest on the part of mining enterprises to produce useful by-product constituents is due to the fact that this requires additional capital investment and more complicated enterprise structure and management. In addition, many scientific and engineering problems pertaining to separating attendant constituents during extraction of the principal element have not yet been solved.

The final process in preparing iron ore for blast-furnace smelting is pelletizing. In 1980 the percentage share of pelletized ore in blast-furnace charges exceeded 90 percent. Analysis of future development of the USSR iron-ore base indicates that the percentage share of pelletized iron ore will increase, as will expenditures on this process.

Pelletizing of iron ore is accomplished by sintering and nodulizing. Sintering has both positive and negative features. Following are drawbacks of sintering: high expenditure of fuel; difficulty of producing a strong sinter capable of standing up under lengthy hauls; poor efficiency of pelletizing finely ground concentrates. The cost of sinter is also steadily increasing. The USSR is the world leader in sinter production volume. At the same time Soviet plants are surpassed by plants abroad in equipment output capacity and product quality. The increase in cost of sinter is due not only to the fact that obsolete equipment is being used but also is due to objective factors: in recent years the percentage share of concentrates smaller than 0.1 mm in size in the sinter charge has continued to rise, which diminishes the productivity of sintering equipment and increases sinter cost.

Worsening of the technical-economic indices of sintering with employment of fine concentrates and increase in their production volumes have dictated the necessity of developing the most promising method of pelletizing fine concentrates -- nodulizing. The end product of nodulizing is iron ore nodular pellets. At the present time we produce for the most part fluxed and unfluxed, metallized and unroasted pellets. Fluxed and unfluxed pellets are employed in coke blast-furnace metallurgy, but in producing pig iron employment of unfluxed pellets is possible only in a combination with basic sinter. Metallized pellets, depending on the degree of metallization, are used for making pig iron and steel. Metallized pellets are one type of pre-reduced iron ore. With a high degree of metallization, various types of reduced ore are employed in steelmaking. Thus sintering and pelletizing of iron ore are initially supplementing one another, while subsequently nodulizing will evidently replace blast-furnace production.

The nodulizing method is more promising than sintering. The sintering process is developing in the direction of increasing the size of the sintering machines together with attendant equipment, by parallel improvement in the quality of the sinter (increasing strength, etc). Its cost is increasing, however, while the cost of producing pellets is decreasing. In spite of the fact that there is taking place, as it were, a countermovement of increase in the cost of sinter and decrease in the cost of pellets, the cost of iron ore pellets is frequently greater than the cost of sinter. In our opinion this attests to the fact that there is occurring a not quite correct distribution of scientific, financial and material resources in the area of scientific and technical development projects between sintering and nodulizing. Accelerated development of the more advanced method of pelletizing fine concentrates -- nodulizing -- will prove to be more economical, which will have a favorable effect on the cost of ferrous metals.

An increase in pig iron and steel production volumes causes an increase in the volume of ore and rock moved by in-mine transport. In connection with the fact that the percentage share of outlays on hauling ore and rock will increase, efficiency of means of transport determines in large measure increase in efficiency of producing merchantable ore. More than 1.5 billion tons of ore and rock are hauled in the USSR iron ore industry: 49.3 percent by rail, 39.4 percent by truck, 10 percent by conveyer, and 1.3 percent by other modes of transport.

In the United States and Canada the bulk of hauling (80 percent) is done by truck. Comparing the basic specifications and performance figures of Soviet-built dump trucks with those built in the United States, we can note that specific horsepower, speed, and load factor are approximately the same, but U.S. dump trucks have less downtime. In the USSR the percentage of the surface-mine truck fleet in serviceable condition is relatively low. A higher percentage is achieved in the United States and Canada through maintenance and maintaining a complete stock of factory-built spare parts. An increase in load capacity and engine horsepower is the principal trend in the development of today's surface-mine motor transport in this country.

An increase in the load capacity of Soviet-built surface-mine dump trucks is in conformity with the world development trend in this mode of transport. As regards powerplants, one way to improve the efficiency of surface-mine dump truck engines is to replace diesel engines with gas turbines. A 1200 horsepower gas turbine engine has been developed in the USSR. The great advantage of a gas turbine engine lies in the fact that it can use liquefied natural gas as fuel; this will make it possible to achieve greater economy and to reduce air pollution around surface mines.

The present iron ore base in the USSR comprises 27.5 percent of total balance-sheet iron ore reserves and makes it possible to provide a crude iron ore production volume in excess of 700 million tons, which corresponds to an annual production of 259 million tons of iron. However, in connection with a worsening of the quality of the iron ore base (a decline in the percentage of iron content in the ore), increasingly deeper mining levels, and an increase in ore hauling distance to the customer, the economic indices of ferrous metallurgy are worsening.

In iron ore beneficiation one should expect changes in technology as a result of total utilization of iron ores. Scientists and engineers are already working on processes for recovering secondary constituents contained in complex ores. The iron and steel industry will be putting out a broader product mix.

Changes are expected in development of methods of preparing ore for smelting. A substantial quantity of concentrate will be nodulized. One can already note a trend toward a steady increase in production of pellets. Production of pig iron will gradually be replaced by a new technique -- direct reduction of iron from ore.

This country's iron ore industry is focusing on more economical utilization of already produced ferrous metals. Up to the present time, however, metal losses are still quite large along the entire process chain, from mining the ore to manufacture of the end product. In the 10th five-year plan, for example, irretrievable metal losses in beneficiation processes totaled approximately 130 million tons, which is equivalent to 400 million tons of crude iron ore.[5] Considerable ferrous metals losses occur in machine building -- from machinery and equipment wear, from shortcomings in organization of collection of scrap metal, poor quality of steels, metal corrosion, etc.

FOOTNOTES

1. See N. D. Lelyukhina, "Ekonomicheskaya effektivnost' razmeshcheniya chernov metallurgii" [Economic Effectiveness of Distribution of the Iron and Steel Industry], Izdatel'stvo Nauka, 1973, pp 116, 118.

2. See T. S. Khachaturov, "Intensifikatsiya i effektivnost' v usloviyakh razvitogo sotsializma" [Intensification and Efficiency in Conditions of Developed Socialism], Izdatel'stvo Nauka, 1978, page 233.

3. See "Dolgosrochnyye programmy kapital'nykh vlozheniy" [Long-Term Capital Investment Programs], Izdatel'stvo Ekonomika, 1974, page 76.

4. Lelyukhina, op. cit.

5. See L. Zusman, "The Metal (Iron) Balance Sheet in the Nation's Economy," VOPROSY EKONOMIKI, No 10, 1979.

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ADVANCES IN ELECTROSLAG METAL TECHNOLOGY

Kiev ELEKTROSHLAKOVYY METALL in Russian 1981 (signed to press 31 Jul 81) pp 4-8, 678-679

[Annotation, table of contents and foreword from book "Electroslag Metal", by Boris Izrailevich Medovar et al., edited by Academicians B. Ye. Paton and B. I. Medovar, Izdatel'stvo "Naukova dumka", 2000 copies, 680 pages]

[Text] This monograph deals with questions pertaining to the quality of electroslag metal, that is, metal materials and blanks of metals obtained by electroslag technology methods: electroslag remelting, electroslag casting, electroslag working, and all methods of enlarging blanks.

This volume contains information on the chemical composition, structure, mechanical, physical-mechanical and industrial properties of electroslag metal: steels of practically all existing classes, heat-resisting alloys, cast irons, and a number of nonferrous, highly reactive and heavy metals and alloys.

This volume presents data on the technical-economic effectiveness of production and employment of electroslag metal.

This book contains reference materials which will be of use to specialist metallurgists and machine builders, designers, students enrolled at higher technical schools, as well as many other specialists involved in the production, consumption and processing of metals.

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FOREWORD

Each year many hundreds of thousands of tons of electroslag metal are produced in this country. The EShP [Electroslag Remelting] metal product list today embraces practically all types and grades of steels and alloys and all types of rolled products produced by the metallurgical industry. They include rolled merchant shapes and wire, plate and sheet, tubes and rings, railcar tires, etc. The assortment of electroslag forgings and drop forgings is quite extensive. More and more varieties of castings, including sectional shapes, are being obtained from electroslag metal.

Bearing and tool steels, structural and high-strength steels, stainless and heat-resisting steels, iron, nickel, nickel-cobalt and iron-nickel-cobalt base alloys, copper and its alloys, transformer steels and alloys, including ferro-aluminum alloys are subjected to electroslag remelting. In recent years highly reactive and even refractory metals have been remelted.

Alongside the remelting process, that is, EShP proper of a consumable electrode, other areas of electroslag technology are also being developed, that is, a technology which employs as heating source Joule heat released in a synthetic slag during the passage of an electric current through it.

Electroslag casting (EShL) is an important new manufacturing process, and particularly such types as shaped and centrifugal casting, based on pouring electroslag metal into a stationary or rotating mold.

Electroslag processes are being developed in which consumable electrodes are used only partially or not at all (electroslag casting, including batch casting, electroslag working electroslag heating, electroslag refining, electroslag feed, etc).

One new application of the electroslag process is its employment in electric furnace melting of steel of metallized iron pellets, electroslag melting of synthetic pig iron of products of direct reduction of iron (pellets, sponge iron).

Whatever one might call a given variation of electroslag technology, its end product is metal, in the form of an ingot or casting, or in the form of a forging or drop forging. In all instances this product bears a common name -- electroslag metal.

Electroslag metal is not only a product of ferrous or nonferrous metallurgy. Therefore we must say a few words about the term special electrometallurgy, which until quite recently was defined rather narrowly, applying only to the production of metal in electroslag and other remelting furnaces. Obviously the time has come to broaden the definition of this term somewhat, bearing in mind that special electrometallurgy and its important subdivision electroslag metallurgy should encompass all those processes in which the electroslag process is employed to melt solid or refine liquid metal.

It should scarcely be necessary here to discuss in detail the great importance for scientific and technological advances of metal of high quality, high reliability, homogeneity, with high indices which are constantly reproduced from one melt to the next, characteristics which describe electroslag metal. One cannot even imagine what would have happened in a number of areas of new technology and the most modern production facilities if metal were the same in its qualitative indices and level of properties as 15 to 20 years ago. Today it is well known that the principal result of electroslag remelting of metal, just as of other refining remelting processes which purify metals of harmful impurities and nonmetallic inclusions, which improve its structure, is a substantial improvement in plasticity and toughness indices with a practically unchanged level of strength properties. This remarkable property of metal freed of contaminating impurities, metal which is sufficiently dense and homogeneous, possessing the required structure, makes it possible, utilizing its margin of toughness and plasticity, appreciably to increase the strength of a steel or alloy. It is precisely this which has made it possible to supply modern machine building with steels possessing very high strength (100-200 kg/mm^2) in fairly large sections, with the required margin of plasticity and toughness. In a number of instances, however, when precisely these two indicators are of decisive significance for the operating properties, reliability and durability of a structural component, machine or machinery part, it makes sense not to seek to obtain the greatest possible strength but rather to utilize in full measure the excellent plasticity and toughness properties of refined metal.

Twenty years ago, during the period of formation of special electrometallurgy, only costly steels and alloys were remelted. In recent years, initially in this country and subsequently abroad as well, there was noted a clearly-marked trend toward employment of EShP in the production of relatively inexpensive medium- and low-alloy, and sometimes common carbon steel. EShP has come into large-scale production, although of course even 10 or 20 years hence electroslag steel will scarcely comprise more than 1-2 percent of the world's total metal production.

We know that party and government decisions call for rapid development of electroslag technology (remelting and casting) in our country. No matter how rapidly this branch develops, however, it is highly unlikely that in the foreseeable future it will fully satisfy the swiftly growing needs of the economy for electroslag metal. This metal is not expensive, but at the present time it is still in short supply. Therefore it should be employed only in those instances where it is truly essential and produces considerable technical and economic effect, that is, when electroslag metal is truly indispensable. Electroslag metal should be employed when it genuinely increases the durability, reliability, and efficiency of a structural component or product. It hardly makes sense, for example, to make engine cylinder liners of EShP metal when total engine life is determined not by the service life of this liner but rather the efficiency and life of the crankshaft or the time to failure of other engine components. It hardly makes sense to make the rolling contacts of bearings of electroslag metal if the rings are made of conventional-process metal. Many such examples could be cited.

When specifying electroslag metal to be utilized in a given structural component, machine or in a given mechanism, designers, process engineers, and production people should consider not only the performance characteristics of this metal but also the economic advisability of such a decision. It is very important here to take the end result into consideration. Frequently the employment of electroslag metal can and does lead to higher product cost, especially in those cases where the cost of the metal proper determines to a significant degree the price of a product. An increase in the service life of a product or improvement in its performance characteristics, however, caused by employment of electroslag metal can and in practice in fact does bring substantial benefits in the area of utilization of this product (machines, mechanisms, structures). Only such a comprehensive appraisal of the effectiveness of employment of electroslag metal will enable us to utilize it most intelligently in industry and construction.

The Communist Party and Soviet Government devote great attention to the problem of improving the quality of metal products and efficient utilization of metal on the basis of adoption of little-waste technology. Electroslag remelting is one of the most efficient means of improving the quality of metal. Other electroslag processes, such as heating, feed, and casting help solve the problem of improving usable metal yield in metallurgical production, that is, in the final analysis foster maximum efficient utilization of metal. Such electroslag technology variants as casting into water-cooled molds, shaped casting and centrifugal casting help solve the problem of reducing labor expenditures in the metalworking industry, of reducing metal losses in the form of chips, trimmings, flash, etc.

In the 11th Five-Year Plan emphasis will be placed on intensive development both of metallurgy and machine building, and on all-out improvement in the quality characteristics of metal and its economical utilization. A thrifty attitude toward metal and complete utilization of available reserve potential and possibilities of achieving metal economies are the business of the entire party and the entire people, stresses the CPSU Central Committee decree entitled "On the Performance of the Metallurgical, Machine Building and Construction Ministries in the Area of Improving Quality of Metal Products and Efficient Utilization of Metal on the Basis of Adoption of Little-Waste Technology in Light of the Demands of the November (1979) CPSU Central Committee Plenum" (see the 8 June 1980 issue of the newspaper PRAVDA).

The many years of experience in the production and utilization of electroslag metal attest to the great prospects for further development and improvement of electroslag technology in the interests of our country's economy.

As electroslag metal production increases, the number of publications pertaining to the quality and properties of this metal is growing both in this country and abroad. Today we are familiar with many thousands of such articles. Nowhere in the world, however, has there yet been published a study synthesizing the countless data pertaining to the physical, mechanical and other properties of steels and alloys which have undergone EShP. This circumstance significantly hinders the task of achieving correct selection of metal and intelligent utilization of its potential.

This team of authors, from the Electric Welding Institute (IES) imeni Ye. O. Paton of the Ukrainian SSR Academy of Sciences and several other organizations which have taken part in writing this volume, was faced with the difficult task of critically interpreting and synthesizing a vast amount of informational material, which is fairly conflictive and sometimes insufficiently reliable. Nevertheless this has been accomplished, and we hope that this book will be of use to the large community of specialists engaged in the production and consumption of electroslag metal.

The authors decided to depart from the standard arrangement generally employed in any book dealing with physical metallurgy or metalworking, that is, from arrangement of the material according to types or classes of steels and alloys. We adopted what we feel is a more suitable arrangement -- merchant shapes, forgings and drop forgings, tubes, sheet and plate, castings, and large-tonnage blanks. Within each of these large divisions the material is arranged according to the traditional scheme -- from common and low-alloy steels to complex and high-alloy steels and, finally, to alloys. The only exception has been made for cast iron and nonferrous metals and alloys.

Inasmuch as the "Naukova dumka" Publishing House comparatively recently put out a book entitled "Elektroshlakovye pechi" [Electroslag Furnaces], equipment for EShP and EShL is treated very briefly in this volume At the same time considerable attention has been devoted for the first time to the general mechanisms of influence of EShP on chemical composition, physical, mechanical, and corrosion properties, as well as on such purely process characteristics as deformability, workability, and weldability.

Chapter I was written by B. I. Medovar, G. A. Boyko and L. M. Stupak; Chapter II -- G. A. Boyko, A. B. Kuslitskiy, Yu. G. Yemel'yanenko, and N. I. Pinchuk; Chapter III -- L. M. Stupak, L. V. Chekotilo, B. I. Medovar, and A. B. Kuslitskiy; Chapter IV -- A. B. Kuslitskiy, S. A. Lebenzon (deceased), Yu. G. Yemel'yanenko, and L. M. Stupak; Chapter V -- A. B. Kuslitskiy, S. A. Lebenzon, A. K. Tsykulenko, L. V. Chekotilo, L. M. Stupak, I. I. Kumysh (deceased), V. Ya. Sayenko, and V. L. Artamonov; Chapter VI -- V. A. Sayenko and A. G. Bogachenko; Chapter VII -- G. A. Boyko; Chapter VIII -- A. K. Tsykulenko, Yu. G. Yemel'yanenko, Yu. V. Latash, A. Ye. Voronin, and V. P. Andreyev; Chapter IX -- L. M. Stupak and I. Yu. Lyutyy; Chapter X -- I. Yu. Lyutyy, L. M. Stupak, and T. V. Novikova; Chapter XI -- B. I. Medovar, I. N. Ivanov, G. V. Bergauz, and A. M. Brechak.

It took more than 2 years from the time the manuscript was ready and the book was published. During this time numerous new data have appeared in the Soviet and foreign technical literature, dealing with the quality of metal materials obtained by electroslag methods.

Of course the authors could not include this data in the text of this volume. Nevertheless, seeking to assist the readers in gaining their bearings in the large flow of new information, the authors of this volume felt that it was necessary to provide at the end of each chapter a bibliography of the most important supplementary literature on electroslag metal published during the time it took for this book to be published.

The authors would be grateful for critical comments which they can utilize in the future.

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FLUORIDE PROCESS FOR PRODUCING TUNGSTEN

Moscow FTORIDNYY PROTSESS POLUCHENIYA VOL'FRAMA: FIZIKO-KHIMICHESKIYE OSNOVY, SVOYSTVA METALLA in Russian 1981 (signed to press 29 Sep 81) pp 2-4, 259-260

[Annotation, table of contents and introduction from book "Fluoride Process of Obtaining Tungsten: Physicochemical Principles, Properties of the Metal", by A. I. Krasovskiy, R. K. Chuzhko, V. R. Tregulov and O. A. Balakhovskiy, edited by Academician V. I. Spitsyn, Izdatel'stvo "Nauka", 750 copies, 261 pages]

[Text] This monograph presents the physicochemical principles of the process of reduction of tungsten hexafluoride by hydrogen and the properties of the obtained tungsten, and examines the physicochemical mechanisms of deposition of alloys of tungsten with rhenium and tungsten carbides.

On the basis of the authors' data, citing the results of studies by other investigators, the authors examine in detail the thermodynamics of the process, its kinetics and crystallization features.

The authors present in sufficient detail the physical and chemical properties of tungsten fluoride as well as the properties of W-Re alloys and tungsten carbides.

This volume is intended for scientific workers, engineers, process engineers, and faculty members of higher educational institutions specializing in the field of gas-phase crystallization of metals.

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INTRODUCTION

The swift pace of development of various fields of new technology demands that we seek and find new technological processes of obtaining coatings and structural materials capable of operating at high temperatures in active corrosive and erosive environments. Among metals which in many cases meet these demands, a privileged position is occupied by tungsten as the most refractory metal, which well withstands variable high-temperature loads and which retains sufficiently high mechanical properties at high temperatures. Another valuable attribute of tungsten is its electroemissive properties.

Until recently the technology of producing tungsten articles was based solely on the widely known metal ceramic method.

Methods of plasma deposition, electric arc melting and electron beam melting are presently being developed. The list of industrial methods of applying tungsten coatings is even shorter. Methods of applying coatings by electrolysis of molten tungsten salts, which have been under development for many years, have failed to produce the desired results, because of high temperatures of the melts on the one hand and their aggressive action on the coated surfaces on the other. Application of tungsten coatings by methods of vaporization by electron beam in vacuum chambers or by cathode vaporized coating produces good results in many cases, but difficulties which arise when coating large articles of complex configuration considerably narrow the field of application of these methods.

Methods of deposition of tungsten from vapor-gas phases have recently begun developing at a rapid pace. As has been demonstrated by the experiments of a large number of investigators, employment of these methods makes it possible, with a comparatively simple process, to obtain both high-quality tungsten coatings and tungsten-coated articles. For this reason there has now arisen an urgent need to synthesize material on industrial processes of obtaining tungsten and certain of its alloys by the method of deposition from vapor-gas phase. This is particularly essential because the most promising method of depositing tungsten by reduction of tungsten hexafluoride by hydrogen, which has already produced important practical results and which was first initiated by the authors of this monograph under the direction of Academician V. I. Spitsyn and Professor Yu. N. Golovanov, has been discussed very little in the literature.

The principal aim of this monograph is to acquaint the broad community of researchers and people in industry working with processes of deposition of metals and metal compounds from vapor-gas phase with new results in obtaining coatings and articles of tungsten and with deposition from a mixture of hexafluoride and hydrogen, and its properties. The material on deposition of tungsten from other volatile tungsten compounds is presented more concisely and is necessary for a full understanding of the advantages and drawbacks of a given method. The description of deposition of a W-Re alloy and tungsten carbide is justified both by its newness and by a common initial raw material -- tungsten hexafluoride.

The book consists of 10 chapters. Chapters 1 and 2 synthesize data in the literature on the properties and methods of obtaining tungsten and tungsten fluorides.

Chapters 3 and 4 examine the physicochemical (thermodynamics, kinetics) and crystallization (structure, grain texture, initial stages of nucleation) aspects of the process of reduction of tungsten hexafluoride by hydrogen and the mechanism of crystallization.

Chapters 5-7 present the physicochemical and physical-mechanical properties of tungsten fluoride, which are of importance for practical utilization of tungsten fluoride.

Chapter 8 deals with the equipment employed in the fluoride process of obtaining tungsten. Chapters 9 and 10 examine the physicochemical principles of obtaining W-Re alloys and tungsten carbides, which in turn demonstrates the broad possibilities of the fluoride process for obtaining not only metals but also for synthesizing metal compounds.

In a number of instances this volume presents differing opinions of various investigators on the substance of the fluoride process of obtaining tungsten. This is due to the newness of the presented material and the authors' desire to present the readers with the opportunity critically to analyze existing ideas on the mechanism of the process of hydrogen reduction of tungsten hexafluoride.

Individual chapters of this volume have been written by the following authors: chapters 1-3 -- A. I. Krasovskiy and V. R. Tregulov; Chapter 4 -- R. K. Chuzhko; chapters 5 and 6 -- A. I. Krasovskiy and V. R. Tregulov; chapters 7, 8 -- O. A. Balakhovskiy; chapters 9, 10 -- A. I. Krasovskiy and R. K. Chuzhko.

The authors will be grateful to the readers for comments and suggestions pertaining to the presented material and would like to give thanks to their collegues who took part in work on the individual items discussed in this volume: I. V. Kirillov, Yu. N. Tokayev, I. L. Sinani, V. P. Kuz'min, Yu. V. Lakhotkin, M. A. Khusainov, Z. G. Mendeleyev, as well as the following persons, who were very helpful in preparing the manuscript: Ye. F. Sorokin, T. V. Rubkin, T. K. Titov, T. K. Maksimov, and M. V. Malandin.

A. I. Krasovskiy

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SCIENTIFIC FUNDAMENTALS OF MATERIALS SCIENCE

Moscow NAUCHNYYE OSNOVY MATERIALOVEDENIYA in Russian (signed to press 30 Oct 81) pp 2-4, 252-253

[Annotation, foreword and table of contents from book "Scientific Fundamentals of Materials Science", edited by USSR Academy of Sciences Corresponding Member Ch. V. Kopetskiy, Izdatel'stvo "Nauka", 1000 copies, 254 pages]

[Text] This volume deals with the scientific principles of materials science. The articles present a picture of the various areas of materials science and of the research being conducted in these areas. The articles are written by leading experts in various areas of materials science. They examine general problems of materials science, its development prospects, and advances in investigation of the properties of various materials.

This volume is intended for a broad group of investigators in various areas of materials science, faculty and graduate students at physics and technical higher educational institutions, as well as engineers working in plant laboratories.

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FOREWORD

As recently as 30-40 years ago the term "materialovedeniye" [materials science] for all practical purposes meant "metallovedeniye" [physical metallurgy]. And although this volume does not touch upon even half the problems and questions pertaining to the scientific principles of materials science, nevertheless it does give a certain picture of the main features of development of this science.

First of all, this development is unusually dynamic. The most diversified materials and methods of obtaining and processing them are becoming an object of investigation. And this diversity is resulting in new materials and technologies, the growth of which, just through possible combinations, should take place in a geometric progression.

Secondly, a physical, quantitative approach to the problem. This distinguishes modern materials science from the descriptive physical metallurgy of the 1930's and 1940's.

Thirdly, employment of modern and ultramodern methods of investigation, the resolving power of which is today at the atomic level.

Fourth, materials science today is a proving ground where the latest ideas and advances in mathematics and computer technology, physics (particularly solid-state physics), physical chemistry, chemistry, and a great many other fields of knowledge are tested and incorporated. If it is correct to state that one can expect the most unusual discoveries at the point of juncture between sciences, it is applicable in full measure to materials science. One should merely consider the fact that the continuous stream of new materials with an amazing combination of what would seem to be mutually exclusive properties (high-strength and heat-resisting alloys, amorphous metals, hard alloys, composites, high-strength ceramics, superconducting materials) and methods of producing and processing them (high-vacuum and zone melting, numerous types of crystallization, quenching at cooling rates of millions of degrees per second, rolling in a vacuum, internal oxidation and nitriding, combustion and explosion, combined heat treatment and mechanical working) has dulled our ability to be amazed. And finally, we must particularly note that the successes of modern materials science are to a significant degree due to development of theory of imperfections in solids. Sequential enthusiastic interest in vacancies, dislocations and, today, grain boundaries and phase interfaces has made it possible to concentrate considerable scientific manpower on theory of imperfections. The picture of an actual crystal has become considerably more complex, but this does not move us further from the truth but rather brings us closer to it.

This volume contains articles by leading experts on numerous aspects of physical materials science. Considerable attention has been devoted to the development prospects of materials science of metallic, composite, and ceramic materials, new methods of producing and studying them, results of experimental study and theory of imperfections in solids. This volume contains papers presented at the 16th Session of "Scientific Principles of Materials Science," dedicated to the 60th anniversary of the Great October Socialist Revolution, organized by the Scientific Council on the Problem "Physico-chemical Principles of Obtaining New Heat-Resisting Inorganic Materials" and the USSR Academy of Sciences Institute of Solid-State Physics in Chernogolovka on 14-16 June 1977.

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INTERACTION OF MOLTEN METAL WITH CARBON MATERIALS

Moscow VZAIMODEYSTVIYE METALLICHESKIKH RASPLAVOV S UGLERODNYMI MATERIALAMI in Russian 1981 (signed to press 26 May 81) pp 2-4, 183

[Annotation, introduction and table of contents from book "Interaction Between Metal Melts and Carbon Materials", by Valeriy Ivanovich Kostikov and Anatoliy Nikolayevich Varenkov, Izdatel'stvo "Metallurgiya", 1150 copies, 184 pages]

[Text] This volume presents modern concepts of the processes of interaction between carbon materials and molten metals. The authors examine the influence of carbon on density, viscosity, surface tension and other properties of liquid metals. They present the fundamentals of theory and results of experimental investigation of the properties of metal melts. They present at a contemporary scientific level theory of wetting and flow, as well as factors influencing the wettability and spread of molten metal on the flat surface of carbon materials. The authors present experimental data on wetting and spread of molten metals on carbon materials. They examine the kinetics and mechanisms of the processes of interaction of carbon with molten metal.

This volume is intended for personnel of scientific research institutes and industrial enterprises. It may also be useful to graduate students and undergraduates specializing in the area of physicochemical investigations of metallurgical processes and obtaining heterogeneous materials.

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INTRODUCTION

The last decade has been characterized by considerable intensification of scientific research in the area of development of heterogeneous materials. Such materials, which consist of components differing in composition and properties, possess elevated strength, hardness, unit strength, as well as a number of special properties which enable us to view them as among the most promising in the development of various structures.

In developing metal-base heterogeneous materials containing carbon material as one of the constituents, great significance is attached to the physicochemical processes taking place at the interface between the various constituents of these materials. The most intensive course of such processes is observed under the condition where liquid metals and metal-base melts, which wet the solid surfaces of reinforcing materials, are employed as matrix material.

With incorrect conduct of manufacturing processes aimed at obtaining heterogeneous materials, certain constituents of the composite, which are in contact with the liquid metal, may partially or completely dissolve in the metal melt, thus reducing the level of properties of the heterogeneous materials.

Therefore employment of a liquid-phase process for producing heterogeneous materials requires knowledge of a number of physicochemical characteristics, as well as the structure and constitution of carbon materials and liquid metals. Such information is essential for studying and understanding the processes which take place at the phase interface between constituents of heterogeneous materials in the process of their manufacture.

Practical experience shows that in order to obtain high-quality metal-base heterogeneous materials with a carbon filler it is essential to have process conditions which provide the possibility of occurrence on the phase interface of processes accompanied by insignificant dissolving of carbon materials in the liquid metal. The occurrence of such reactions, however, should not be accompanied by loss of the properties of the carbon filler. Therefore essential for a directed process is a quantitative estimate of the interaction between the carbon material and liquid metal, which in large measure is determined by the physicochemical properties, structure and constitution of the solid and liquid materials in contact.

This book reflects the results of the research conducted by the authors, and basic concepts on the structure and constitution of carbon materials and liquid metals are presented at a contemporary scientific level. The authors examine general questions pertaining to capillary and contact phenomena at phase interfaces. Experimental data are presented on the processes of interaction between liquid metals and carbon material.

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